

II. GEOCHRONOLOGY: METHODS AND RESULTS

A. General Aspects of Dating in the Field of Archæology

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During the last three decades, archæologists have fairly well abandoned one of their favourite games; that of 'guesstimating' the age of an item or event. The dating of early prehistoric events was based more on guess work than on estimations; for the late prehistoric periods, good estimates could be deduced with less guess work. In the very late period, historical documentation was of considerable assistance whenever it could be applied, and several techniques were devised for aid such as seriation, typology, rate of accumulation, cross-identification, and stratigraphical associations. Many of these age estimates were very good especially when they were based on wide, practical experience. There was no definite way, however, to prove the date one way or another; the matter of temporally placing in terms of years a prehistoric event or item remained a never-ending problem.

With the advent of dating techniques based on physical and natural sciences, archæologists and others thought that finally here were methods which could give to them specific answers to all their dating problems. Gradually the idea became a fixation that laboratories had magic boxes with lots of dials and numbers into which an object could be placed, a few handles turned, and the date read off a dial. Is such a procedure feasible for dating archæological events and items? The answer must be a definite and emphatic NO.

'Magic boxes', some of which are capable of extraordinary processes already exist, but they are no better than the operator and the date programmed into their working mechanism. Laboratory analysis can be likened to a similar situation in which an archæologist requests a geologist to identify the type of rock used in making an artifact. The geologist does this but he does not interpret the rock in terms of its form, use, or function within the group responsible for its manufacture. To use raw 'data' supplied by the laboratory as an archæological date is no more valid than to use the type of rock in relation to the function of an artifact. No laboratory 'date' is valid simply within its own right. Each set of data must be evaluated in terms of the material analysed, the limitations and restrictions imposed by the physical character of that material and its association to the event under study. The archæologist must take this laboratory data and analyze it in terms of his problem before he can apply a 'date'. The problem of 'guesstimating' an archæological date is still with us.

With a broad array of techniques available today, the field investigator must have some knowledge of what to collect and how to collect it because his interpreted date is no better than his field observations. Datable materials are similar to people. If you walk down any street asking the age of each person whom you meet, you find that your answers fall into three general categories. Most of the people either ignore you or tell you it is none of your business. Some of the remainder give you a rather

evasive answer such as that they were over 21 (and they are obviously younger than 100), and the few remaining individuals give to you a straightforward answer. Materials are much like people; most of them simply ignore us and tell us nothing; a few give a rather evasive answer; and only a small number yield direct information.

To make a valid interpretation of the laboratory and field data, it is essential to have a fairly complete understanding of the situation especially on the five following points.

1. The first is, what should an archæologist collect? There is no logical answer to this question because, until you know which materials will yield temporal information, it is impossible to predict what material will be of value. Materials of seemingly worthless value today may however become invaluable tomorrow with the advent of some new technique. The safest way to overcome this problem is to keep a sample of all animal, vegetable, and mineral matter encountered. Even a small sample of currently worthless material, such as a vial of soil, may be of importance for pollen and other microfossil and macroorganic studies.

It is best to collect grasses and other types of annual plants for radiocarbon analysis. In this way the chances of obtaining a narrow 'time-range' are much better than they are from a piece of wood that has many years' growth. Bone and shell are perhaps the poorest type of material for radiocarbon, because the former tends to concentrate radiocarbon and the latter often contains varying amounts of dead carbon. It is not the size of a wood specimen that matters when it is submitted for tree-ring dating, rather it is the number of rings present and the condition of the outside of the specimen—take extreme precaution to preserve this outside. Teeth are the most important parts of an animal you can submit to the palæontologist, long bones are of little value especially when they do not contain the epiphyseal ends. *American Antiquity* of April 1961, 26(4), 538–540, has an article by S. J. Olsen on this very point.

2. The second point is on the type of material to be collected according to the time range involved. It would do little good to collect radiocarbon samples if one has a temporal problem dealing with the early Pleistocene, because the time range for radiocarbon dating is approximately 45,000 years. It is equally obvious that to collect mineral samples for potassium-argon dating has little value, if one is working with a temporal problem concerned within the last 10,000 years. This does not mean that you should discard wood samples if you were to find them associated with, say, a mid-Pleistocene site. Other information can be gained from the material that in itself is of value; such as the species of the plant, the climatic implications that can be deduced from cell and ring structure, and its possible use as an artifact. It is necessary, for these and other reasons, to make a species identification on all plant material submitted for radiocarbon work. Trace elements in the soil are taken into the plant on a temperature-moisture basis, consequently through emission spectrography, the plant material can be burned and the amount of trace elements determined by the spectrum. High manganese content, for example, indicates (under certain conditions) that the temperature is relatively cooler and/or wetter than it had been; low values reflect drier and/or warmer climates.

3. The third point stresses the information needed on the emplacement of objects or materials submitted for analyses. Simply because some item has been

found in a site does not necessarily mean that the object has a direct bearing on the sediments in which it has been found. Its position there may be accidental or intentional, it may have been emplaced naturally or artificially; it may or it may not be of specific value in dating the matrix or associated materials. The mode of em-
placement of charcoal pieces may tell you whether a building burned or not and whether the fragments collected were part of the construction, or if the specimens were part of trash material dumped in at a far later date.

One of the more difficult aspects of dating any prehistoric item or event is the determination of the exact association of the material dated to the event or the item in question. Simply because two objects are found in close proximity does not necessarily mean that they were associated with each other at the time the event took place. Tree-ring dating is one of the better means we have for establishing controls to aid us in our interpretation of data which results in archæological dating. The reason for this is that with the exactness possible in tree-ring dating, the detailed sequence of events can be accurately constructed. In the south-western United States thousands of tree-ring dates have been worked out, and it is comparatively easy now to know whether or not a date on a specific specimen is indicative of a particular cultural period. For example, in this area there is a particular cultural horizon commonly called the Pueblo III Period. Dates on this normally range from about circa A.D. 1050 to 1300. Because of its masonry and other cultural items, a particular structure found in a cliff shelter was placed in the Pueblo III Period. A wood beam that had good bark on the outside was found embedded in a wall of this building. Dating the beam posed a problem because the terminal growth on the tree occurred in the year A.D. 666, many years before the Pueblo III horizon. Re-examination of the site showed that, buried deep underneath the Pueblo III debris were items belonging to a much earlier culture called the Basketmaker Three Period, which normally dates during the A.D. 400-700 period. The only interpretation that can be put on the date was that the Basketmaker people had brought this log into the cave for some purpose which did not cause its destruction. The dryness of the cave over the centuries is such that there had been no deterioration of the log. Centuries later when the Pueblo III people came into the cave and wanted to construct a building, the log was found and, because of its soundness, was incorporated within the Pueblo III wall. Here is an obvious case where a bit of material was actually incorporated within a structure, yet upon dating it indicated that its bearing on the time of construction of the wall was very evasive. We have found in tree-ring dating that there are numerous cases of re-use of old materials which make the date much too early, and that there are many cases of repair of old structures which give the date much too late. To reiterate, one must not assume that because two objects are adjacent to each other in a matrix they both are of the same age and were deposited under the same conditions.

4. The fourth point is that each dating method has within its physical characteristics numerous limitations and restrictions. These must be carefully considered when interpreting the analyses in arriving at an archæological date. An example here would be where one has a piece of tree material with no indication of the true outside. Without such an indicator, it is impossible to know when the terminal growth actually occurred on the tree. The outermost ring which can be dated,

while accurate for the specimen, may have little or nothing to do with the terminal growth except that it had to precede it. This situation could be entirely misleading in the case of long-lived trees; some we know have lived for over a thousand years. This example can also be applied in radiocarbon work, because radiocarbon dating gives the average age of the rings studied; in no way can it tell when the tree died except that it died after that particular time. The use of bone and shell for radiocarbon dating leaves much to be desired, as already said. The degree of accuracy with which bone and shell can be used is much wider than it is in the case of annual plants, which we know concentrate in one year's time all of their radioactive material.

5. The question naturally arises of what must the archæologist do to interpret laboratory analyses in terms of dates and this is my fifth point. The analyses are as accurate as modern science can make them. Technicians are constantly striving to improve the accuracy of their instruments and techniques used. As stressed earlier, the laboratory technician cannot give an archæological date to a particular event or item. All he can do is analyze the material and give the results of this analysis to the archæologist who must in turn take it and through a process of interpretation arrive at the temporal placement of this material in terms of the calendar years. This type of an approach to archæological dating is fairly well dependent upon six subpoints which are: *i.* a date is directly applicable to the specimen submitted for analysis; *ii.* a derived date on any material gives one end of the time limit involved, the other end being the present when the analysis is carried out; *iii.* a derived date to have any meaning must be accurately associated with some phenomenon—either an event or an item; *iv.* isolated dates at most are indicative of a particular period of the sequence and do not represent true chronology; *v.* as many dating methods as are applicable to every problem should be utilized; and *vi.* a complete integration of all basic data into a composite reconstruction of the physical history should be made.

In tree-ring dating, the archæologist knows that the tree was a live, growing, botanical entity at the time when the last seasonal growth was deposited. It stands to reason that the construction of a house, or the use of that tree in some other architectural or functional feature, could not have occurred until after the tree died. How long after the terminal date before the tree was used remains a problem for the archæologist. The archæologist must, therefore, through his field observations determine how the tree was used; under what conditions it was used; when it was used; and, unless it is still an integral part of the wall or some other feature, how did the specimen get to where it was when found by the archæologist. This means that he needs to reconstruct the story of that particular specimen from the time it was a living tree until he found it in the site in question. I might liken this to the discovery of one sherd. A single sherd does not make a pot; it simply means that pottery was made some place in that area, and a part of it still remains. A single date does not mean that the people were there at that particular time; it simply means that there were trees growing in that area during the time in question.

Part of the task assigned to me in this discussion was to cover several of the major dating techniques being used today which are, or may be, of benefit to archæologists. I generally group these techniques into three major categories. These are: *i.* relative

placement methods which include stratigraphy, palæontology, pollen analysis or palynology, fluorine analysis, geomorphology, thermoluminescence and others; *ii.* time placement methods such as radiocarbon, potassium-argon, alpha-helium, ionium, varves and others; and *iii.* absolute placement methods which has but one entry, dendrochronology or tree-ring dating as it is commonly called.

In Relative Placement, time can only be implied as being previous to, contemporaneous with or later than another event. Time cannot be considered here in terms of years or as a theoretical unit of measurement. Time Placement methods attempt to place in terms of year a definite date on events, but because each method must incorporate within that placement a certain error, the results are given in intervals of time rather than in points of time. Absolute Placement refers to the methods which potentially can date material to a definite calendar year.

Dating techniques which are in use today are not the result of deliberately setting out to find some methodology which will date an event or an item; rather they are the results of other investigations that can be applied to temporal problems. Tree-ring dating was started as an attempt to find a longer record of sun-spot activity, and its application to the field of archæology was a by-product of this investigation. Radiocarbon dating was the result of investigations conducted by physicists into various radioactive isotope studies. Thermoluminescence began as a study of the crystalline lattice work of various rocks and minerals. You as archæologists certainly understand that when people of a particular culture borrow or otherwise adapt some item from another culture into their group, there is always some change in the form, use, or function of that item. Certainly when we remove from the physical laboratory certain techniques and use these in dating problems, we have to base our interpretations on certain assumptions which quite often cannot be well verified.

I shall elucidate this point by using an example of radiocarbon work. I will state that all radiocarbon analyses coming from the laboratories are absolutely accurate for the material analyzed. In other words, every radiocarbon date is correct. This does not mean that every application of that analysis to an archæological or geological problem is correct. All that any radiocarbon analysis does is simply to take the ratio between the existing non-radioactive carbon 12 and the radioactive carbon 14 isotopes, and on the basis of the disintegration process, arrive at a time when the material was a live substance. This ratio may have been subsequently disturbed through natural or artificial causes, and this cannot be determined on the basis of the laboratory analysis by itself. We are wrong, then, in assuming that all analyses are perfectly valid for the dating of a prehistoric event. The original premise that the ratio between the two types of carbon will give us a date is still correct. What is needed is much more study of this ratio, and why it can and often is disturbed through other media. It is up to the field of archæology therefore to sponsor considerable research into this type of activity and try to improve the use of radiocarbon analyses for archæological dating. In the case of tree-ring work, the dendrochronologist can give the date of the last ring present on the specimen. If bark or other indicative means are still present, he can tell the terminal year of growth of that particular specimen. It is impossible for him, however, to state from his position in the laboratory that the tree was cut in a given

year and incorporated in a building that same or the following year. This, and other similar questions, remains a problem for the field of archæology to solve.

Pollen analysis, or *palynology* as it is called, is becoming rather important to the field of archæology in as much as it can in many instances help determine when particular food products were first used, the intensity with which they were used, and the time when they ceased to be used by a given group. The pollen specialist can take the matrix, extract the pollen grains from it, identify those grains, and come up with some sort of a pollen profile. He cannot, however, interpret this data in light of archæological evidence; this remains a task for the archæologist. The three examples which I have given here simply illustrate that it cannot be the sole job of either the archæologist or the laboratory technician to come up with the logical interpretation. There must be exceedingly close co-operation between the professional groups. Neither group will make progress by simply sitting back and making the statement that any particular analysis doesn't fit the situation as seen by the field-man; this will not help matters at all. The field-man can often assist the technician by submitting several different types of material from the same horizon; by giving ideas as to what has happened in the field in regard to the materials in question; and by being willing to help in the application of laboratory analyses. The laboratory technician, on the other hand, can often give the field-man considerable assistance by pointing out that two seemingly contemporaneous materials were actually not contemporaneous, or that two totally unrelated events might actually be the result of a common event, and so on.

I would now like to take a few minutes to discuss some of the more important advances made in several dating fields, which are of value to the field of archæology. There is little need, nor does time permit, to discuss in detail the mechanics of any single technique. On a world-wide basis perhaps no dating technique can approach the importance of radiocarbon. We have learned in the few short years of its existence that it is not the universal answer to all temporal problems either in archæology or any other field. Certain materials give more reliable results than others, and certain conditions will yield more reliable results than will other conditions. The use of new counting media has made possible a more accurate analysis—particularly on the upper end of the time scale. This has been brought about by the reduction of the background count through better shielding, and through more precise anti-coincidence circuitry, as well as the improvement of the counting medium. Less sample material is also now required for analysis because of these newer media.

In the field of dendrochronology perhaps the more significant developments centre around the refinement of technique. A better understanding is being sought, particularly in attempts to determine terminal growth for specimens which have no indicators such as bark, galleries of constant outermost rings. More detailed studies are being made on the time of construction following the terminal growth period. Also of importance is the use of tree-ring information to obtain data on past climatic conditions. The latter will be of particular benefit for archæologists working in cultures which derived their food supply primarily from dry-land farming. Also of considerable importance in an indirect way is the part tree-ring dates are playing in the attempt to better understand the application of dating

techniques to archæology, and the use of tree-ring dated beams in half-life and other studies connected with radiocarbon research.

In the field of palæontology there is more emphasis now being placed on the value of fossil animals as ecological indicators. To do this it is necessary to make a much more precise species identification and classification of all remains present in any given midden material. The work in this field goes hand in hand with the advances made in the field of pollen research; the latter striving to determine what the plant life was like at the time of deposition.

In the field of radioactive dating such as with the use of potassium-argon, helium, and so forth, there is now considerable hope that the more recent limit of applicability can be extended up into the last hundreds of thousands of years instead of the last few million of years. The recent publicity on the dating of Leakey's material from Africa attests to the desire and need for better dating in this range of time.

In the meantime new techniques such as tephrochronology (concerned with the study of volcanic deposits), thermoluminescence (study of the change of the lattice work in certain rocks and minerals), obsidian analysis (the penetration of obsidian by water), and many others are being tested and explored. None of these are reliable at the moment and all must be considered as exploratory techniques. Many good tests for relative placement are also being studied such as the use of fluorine, uranium and nitrogen content as recently reported by Oakley and Howells for the skeleton from the Lagow Sand Pit in Texas.